

Early Assessment of Mild Alzheimer's Disease Using Elman Neural Network, LDA and SVM Methods

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Abstract: This research provides a process for diagnosing the mild Alzheimer's disease from the brain signals. Due to the material and spiritual costs of nursing, caring and treatment of this disease, the early accurate diagnosis would be much useful. Considering the effect of the mild Alzheimer's disease on electroencephalography (EEG), the mild Alzheimer would be diagnosed within the early steps by an appropriate process. First, the brain signals of healthy people and patients are registered for four states: closed-eyes, opened-eyes, recall and stimulation, in three channels Pz, Cz and Fz. Then, optimal features are drawn out by using an Elman neural network and two classifiers applying genetic algorithm: linear discriminant analysis (LDA) and Support vector machine (SVM). According to the results of testing phase, among the three channels and four states, Elman neural network is much more efficient for Alzheimer diagnosing in Pz channel and the state of irritation in comparison with LDA and SVM in the other channels and states.

Keywords: Mild Alzheimer's Disease, Neural Network, Electroencephalography, Genetic Algorithm

1. Introduction

Alzheimer's disease (AD) is a neuro-degenerative disease which decreases the mental power and is commonly seen in elderly people [1], [2]. The dominant symptoms of the Alzheimer's disease include memory loss, lack of judgment, rationality power, and crucial changes in behaviors [3]. There is no perfect way of diagnosing and certain method of cure for this disease [4]. The number of Alzheimer patients in Iran has been doubled to 2.2 for 13 years [5]. Furthermore, the treatment costs are too expensive, and also caring and nursing are much difficult. There are several years between the occurrences of early symptoms and approaching to severe status of disease. In the case of late diagnosing, the new method of cure will not be effective. The best solution is to identify the mechanism of this disease and its effect on the brain signals and attaining this goal is demanding and extremely difficult, because of dynamic characteristic of event related potential (ERP), electroencephalography (EEG) signals as well as the sophisticated nature of this syndrome.

There are different methods in the field of imaging for diagnosing the Alzheimer's disease. At the same direction, two issues are very important: First is the substantial cost of the treatment processes, and the second is lack of certainty in the result attained [6]. Therefore, it is important to seek for less expenditure methods with the appropriate accuracy and precision. Medical diagnosis of Alzheimer's disease is usually difficult, and symptoms are often dismissed as normal consequences of aging. Diagnosis process is usually performed with an extensive testing. Psychological tests such as Mini Mental State Examinations (MMSE), spinal fluid, blood tests, and imaging techniques are applied to diagnose the Alzheimer's disease [7, 8, 9, 10].

The following paragraphs first describe methods and materials for brain signals recording and preprocessing. Then, the proposed approach is discussed for sample classification. Finally, the results and accuracy of the classification methods are presented.

2. Methods and Materials

In this study, 32 people including healthy, patients with severe, and less severe state have been selected. They have been examined by a physician through clinical.

2.1. Clinical Diagnosis of Examinations

One of the appropriate measures for labeling examination is Mini-mental state examination (MMSE). In this research, dementia rating scale (DRS) is not used because of its time consuming. The labels administered as healthy, less severe patient and severe patient. During the examination, there should be a difference between the two groups of literates and illiterates [4], [5], as shown in Table 1.

Table 1. MMSE threshold for literates and illiterates.

Illiterate	Literate	State
$22 \leq \text{MMSE} < 30$	$23 \leq \text{MMSE} < 30$	Healthy
$0 < \text{MMSE} < 22$	$0 < \text{MMSE} < 23$	AD
$19 \leq \text{MMSE} < 22$	$20 \leq \text{MMSE} < 23$	Mild AD
$0 < \text{MMSE} < 19$	$0 < \text{MMSE} < 20$	Severe AD

2.2. Brain Signal Recording and Preprocessing

To record brain signals, three channels Pz, Cz and Fz of unipolar have been used. Because the goal is to record total activities of brain and for the study of EOG activity procedure and its effect on electrical activity of brain in an Alzheimer patient, a bipolar canal has been applied to record electrical activity of the eye. To record brain signals of tests the following procedures have been employed as follows, Teaching examination, recording with closed-eye for 1 minute, recording with opened-eye for 1 minute, and recording the examination's signals during performing tasks including remembering the shapes displayed and counting the targeted and untargeted sounds in the listening Oddball protocol. Labeling on the examination, the physician explained the four steps and procedures and the characteristics of targeted and untargeted sounds. When the examination is prepared the second step is administrated. The signals are recorded in closed-eye state for 1 minute. In the third step, the examination is required to open his eyes to register the signals for 1 minute. Some pictures used to examination are shown for 1 minute, as shown in Figure 1. Then he was asked to close his eyes and retrieve them in his mind while his signals are recorded for one minute and consequently he was required to open his eyes and describe the pictures one by one with a loud voice. In the final stage, the examination is taught to distinguish the targeted and untargeted sounds by pressing the right key for target sound and the left key for untargeted sound. Then the two sounds with the frequencies of 1 and 1.5 kHz were played randomly. The interval between stimuli is 2 seconds. Regarding this point that 75% of stimuli are targeted and 25% of them are untargeted. If it is supposed that the total number of stimuli is 120, the number of targeted stimulus is 30 and untargeted stimulus is 90 which were played randomly among one another [11], [12].

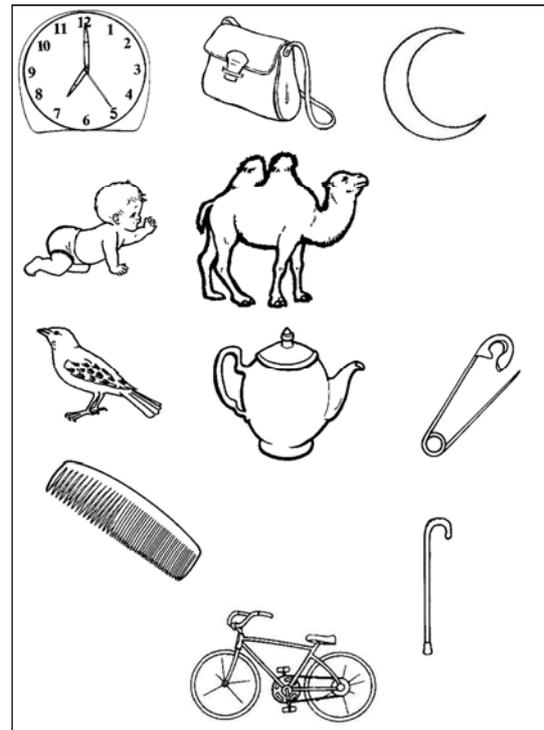


Figure 1. Pictures shown in the examination.

In this study 32 people were employed for recording their signals. The range is between 60–88 years old. From among them, 19 healthy with the points attained of MMSE in the range of 23–30, average 27.57, and standard deviation 2.19; 7 less severe patients with the points attained of MMSE in the range of 19–22, the average 20.71, and standard deviation 9.95; and 6 severe patients with the points attained of MMSE in the range of 3–18, average 13, and standard deviation 6.09.

To process the signals appropriately, the first step is to take the suitable EEG to avoid interference and turbulences. To attempt this issue, five steps are intended including deletion of deviation from baseline, deletion of artifacts of high and low frequency, removing the electrical noise, and the reduction of sampling rate and part assembling. It goes without saying that through the removing of redundant information from EEG signals, the quality and accuracy of next processing are increased. The artifacts in EEG signals are of two types—the artifacts of high frequency of EEG such as the muscles of head and neck, and the artifacts of low frequency resulted of electrode movements and sweating. To remove these artifacts as well as electrical noise, a mid-pass filter with the cut frequencies of 0.5 to 45 kHz is applied.

2.3. Optimal Features

Prior to appropriate preprocessing of signals, the statistical, spectral, timed, frequency, and linear features have been taken into consideration. After the identification of different features, computation and optimal feature is targeted. To approach this, the GA method has been used. In this study, axis of features in three state of closed eye, open eye, and recall period containing 37 features. In the recording set of stimulation period. The axis of features contains 45

features [6].

2.4. Genetic Algorithm

The genetic algorithm is a method for solving both constrained and unconstrained optimization problems that is based on natural selection, the process that drives biological evolution. The genetic algorithm reclaims a population of individual solutions. At each step, the genetic algorithm selects individuals at random from the current population to be parents and uses them produce the children for the next generation. Over successive generations, the population evolves toward an optimal solution. You can apply the genetic algorithm to solve a variety of optimization problems that are not well suited for standard optimization algorithms, including problems in which the objective function is discontinuous, non-differentiable, stochastic, or highly nonlinear.

The genetic algorithm applies 3 main types of rules at each phase to create the next generation from the current population: *Selection rules* select the individuals, called *parents* that contribute to the population at the next generation. *Crossover rules* combine two parents to form children for the next generation. *Mutation rules* apply random changes to individual parents to form children.

2.5. Classifications

The ultimate aim in each problem is pattern identification, classification of samples in tow or some different classes. In the supervised method, a set of labeled data is applied as educational set for adjusting the classifying parameters.

Therefore, in this study, three linear classifying distinguishers (LDA), Support vector machine (SVM) and neural network (Elman) have been used, the goal was to compare the classifiers of static and dynamic [13].

4. Discussion

Table 2. Results of accuracy of LDA, and SVM with three nucleuses linear, poly and RBF, and performance of Elman neural network on three channels of Pz, Cz and Fz in four states closed-eye, opened-eye, recall, and stimulation.

	Fz				Cz				Pz			
	Open	Close	recall	Stim.	Open	Close	recall	Stim.	Open	Close	recall	Stim.
SVM linear	59.9	61.4	62.1	63.9	66.4	65.1	65.9	66.5	67.3	68.9	71.4	59.9
SVM poly	61.4	62.3	63.1	65.1	65.8	66.8	67.1	67.4	68.4	70.1	73.3	61.4
SVM RBF	63.3	64.1	65.9	66.1	67.4	69.3	70.1	69.7	71.3	72.3	76.1	63.3
LDA	47.3	48.7	52.3	56.1	50.4	57.4	57.7	60.0	60.1	61.9	65.1	67.4
Elman	78.4	80.4	82.5	85.1	82.6	87.2	86.8	90.8	91.8	93.8	95.7	96.4

A accurate and early assessment of Alzheimer's disease is necessary to reduce the the material and spiritual costs of nursing, carring and treatment of the disease. The presented approach for diagnosing the mild Alzheimer's disease is based on EEG signals of healthy people and patients processing. Brain signals are registered in four states: closed-eyes, opened-eyes, recall and stimulation, in three channels Pz, Cz and Fz. The classification of healthy and patient is

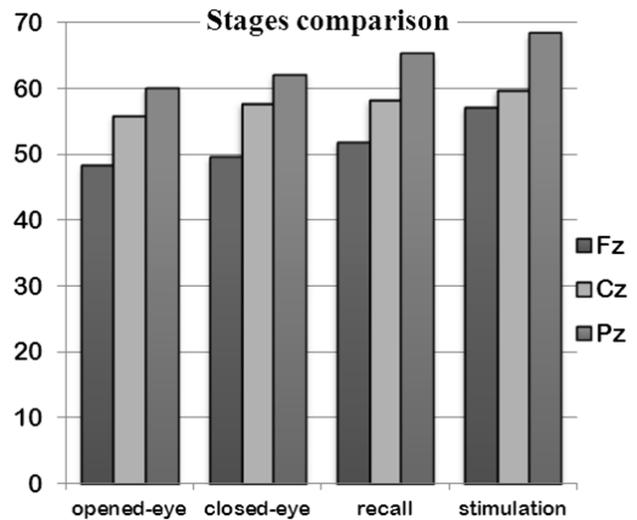


Figure 2. Assessment of four states of Fz, Cz and Pz in GA.

3. Results

In four states closed-eye, opened-eye, recall, and stimulation the sort of optimal features among the channels Pz, Cz and Fz are shown in Figure 2. Then linear distinguisher is applied on three classes of optimal features attained from GA. The accuracy of results of LDA and SVM with three nucleuses linear, poly and RBF on three channels of Pz, Cz and Fz in four states closed-eye, opened-eye, recall, and stimulation are shown in Table 2. Also the abstracted features of each section is labeled with a label of the same section in the final state regarding the neural network due to the linear features of the question and the dynamic of non-linear signal of EEG. The accuracy performance of Elman neural network in the test phase is shown in Table 2.

performed by applying Elman neural network, LDA, and SVM.

5. Conclusion

The results show that the states of recall and stimulation are the best for diagnosing the disease because of the addition of optimal features of these two states to evaluate with the

methods of the genetic algorithm. Also channel Pz includes more optimal features for diagnosing the Alzheimer patients compared to the two other channels. The method of neural network of Elman shows the higher level of accuracy of performance for diagnosing the mild Alzheimer's disease compared to the LDA, and SVM methods.

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